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COMMISSION STAFF WORKING DOCUMENT

Climate change adaptation, coastal and marine issues

Accompanying the document

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

An EU Strategy on adaptation to climate change

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An EU Strategy on adaptation to climate change

1. INTRODUCTION

This staff working document accompanies the Communication "An EU strategy on adaptation to climate change". Together with the Impact Assessment, it provides further background material supportive of the narrative and arguments put forward in the Communication.

The Communication "An EU Strategy on Adaptation to Climate Change" stresses that coastal zones are particularly vulnerable regions, and also indicates that the EU's outermost regions are particularly vulnerable to sea-level rise and extreme weather events.

This staff working document follows up on the "Climate Change and Water, Coasts and Marine Issues" paper[1] which accompanied the 2009 White paper on adaptation[2].

This paper aims to provide an overview of the main impacts of climate change on coastal zones and marine issues, not only considering its impacts on the environment but also on economic sectors and social systems. Furthermore this document points out knowledge gaps and existing efforts of the European Union to best adapt to the impacts of climate change on coastal zones and marine issues. In addition, it also highlights further efforts needed, in particular regarding closing knowledge gaps for better-informed decision-making, as well as better cooperation between Member States across borders to make Europe more resilient to climate change.

2. IMPACTS OF CLIMATE CHANGE ON COSTAL ZONES AND MARINE ISSUES

Coastal zones and marine waters have already been greatly affected by rapid urban development, draining of coastal marshes, changes in river and sediment flow, expansion of irrigation for agriculture and unsustainable fishing practices. Climate change increases the pressure on already-fragile ecosystems. It has already had an impact on sea temperature, sea-level rise and ocean acidification. These changes have had a follow-on impact on ocean circulation, coastal erosion, biodiversity and ecosystems. The frequencey and intensity of most types of extreme weather events is expected to change as a result of climate change[3]. All of these changes affect coastal populations and the marine and maritime economy.

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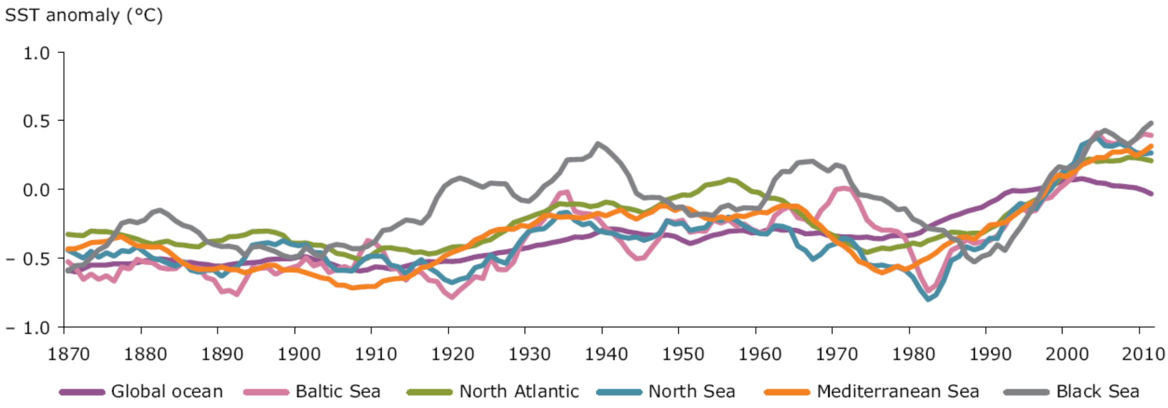
1 Commission Staff Working Document accompanying the White Paper "Adapting to climate change: Towards a European framework for action", Impact Assessment, SEC(2009) 387. Brussels, 1 April 2009.

2 Commission White Paper, Adapting to climate change: Towards a European framework for action, COM(2009) 147 final. Brussels, 1 April 2009.

3 http://ipcc-wg2.gov/SREX/images/uploads/SREX-SPMbrochure_FINAL.pdf

2.1. Impacts on environment

2.1.1. Increased sea temperature



Note: Time series of annual average sea surface temperature (°C), referenced to the average temperature between 1986 and 2010, in each of the European seas.

Sources: SST datasets from the Hadley Centre (HADISST1 (global)), MOON-ENEA (Mediterranean Sea), and Bundesamt für Seeschifffahrt und Hydrographie (Baltic and North Seas), and MyOcean.

Figure 1 Sea surface temperature[4]

Whilst there has been considerable variation from year to year and from region to region, the surface temperature of Europe's seas has risen significantly over the past century (see figure 1). Increases in sea surface temperature have been greatest in the Baltic Sea and the North Sea, with lower rates identified in the Black Sea and the Mediterranean Sea[5]. Measurements are scarcer at depth but at a global level it has been estimated that 69% of the increase in heat content occurred in the upper 700 meters[6]. Increased sea surface temperature– coupled with changes in precipitation, wind and salinity – influences sea ice coverage as well as the diversity and number of marine species[7].

2.1.2. Change in ice cover

Increasing temperatures have had the most dramatic impact on the Arctic. Over the past 60 years, the extent of Arctic sea ice at the end of summer melt has declined at a rate of -7.8%/decade; the last 20 years have seen a trend of -9.1%/decade[8]. Current projections[9] indicate that summer ice is very likely to continue to shrink in extent and thickness. In this context, an important phenomenon is the ice-albedo feedback loop. The albedo - the amount of solar radiation reflected by a surface – of snow and ice is 0.8 or 0.9[10], i.e. very little solar radiation is absorbed. In the Arctic, the melting and cracking of ice sheets exposes darker ice as well as sea water. As a result, more solar radiation is absorbed, which causes more ice to melt. Although this is a normal seasonal process in the summer, the increase in the melting of ice associated with climate change will aggravate this feedback loop. Increased sea surface temperature– coupled with changes in precipitation, wind and salinity – influences sea ice

4 Climate change, impacts and vulnerability in Europe 2012, European Environment Agency, 2012
5 EEA (2008).
6 IPCC Fourth Assessment Report: Climate Change 2007
7 EEA (2008): Impacts of Europe's changing climate – 2008 indicator-based assessment.
8 Stroeve, J., Holland, M., Meier, W., Scambos, T., Serreze, M. (2007): Arctic sea ice decline: Faster than forecast, Geophyscial Research Letters, 34.
9 Stroeve, et al (2007).
10 Albedo is calculated on a scale from 0 to 1 where zero is no reflecting power of a perfectly black surface and 1 represents perfect reflection of a white surface.

coverage as well as the diversity and number of marine species[11]. For instance, a decreasing trend in the Baltic Sea's ice cover has been seen in 15-year average over the past 200 years[12].

2.1.3. Sea level rise

The global sea level rise that had been levelling off after the steep rise following the end of the ice age has accelerated over the past two centuries. The average increase in sea levels around the world over the 20th century has been about 15 to 20 centimetres. Considering the last decade the average rate of sea-level rise has increased to about 3.2 cm[13].

A modelling exercise by Marzeion, et al. (2012)[14], based on observed climate data, indicates that the world's glaciers have already lost mass equalling 114 ± 5 mm sea-level equivalent (SLE) between 1902 and 2009.

In its Fourth Assessment Report (AR4), the IPCC projected global average sea-levels rise between 18 cm and 59 cm for the end of the 21st century, depending on greenhouse-gas emissions scenarios and climate change sensitivity. Contributing factors to the IPCC estimates are thermal expansion (10 to 41 mm), followed by melting of glaciers and ice caps (7 to 17 mm) and Greenland Ice sheet (1 to 12 mm)[15].

Some recent studies have shown that sea-level rise could be even more significant[16]. This is largely due to ice sheet dynamics, knowledge of which is still hindered by the robustness of the models[17]. The warming of the atmosphere and oceans is leading to an accelerating loss of ice from the Greenland and Antarctic ice sheets, and this melting could increase the rate of sea-level rise in the future substantially[18]. More robust projections would ease decision-making on adaptation.

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11 EEA (2008): Impacts of Europe's changing climate – 2008 indicator-based assessment.

12 Omstedt et al, Baltic Sea climate: 200 yr of data on air temperature, sea level variation, ice cover, and atmospheric circulation Climate Research Vol. 25: 205–216, 2004

13 Available at: http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

14 Marzeion, B., Jarosch, A.H., and Hofer, M. (2012): Past and future sea-level change from the surface mass balance of glaciers. The Cryosphere, 6, 1295-1322.

15 IPCC, 2004 in EEA (2012): Climate change, impacts and vulnerability in Europe 2012. An indicator-based report.

16 e.g. Rahmstorf, S., 2007: A semi-empirical approach to projecting future sea-level rise. Science, 315, 368-370; Vermeer, M. and S. Rahmstorf, 2009: Global sea level linked to global temperature. Proceedings of the National Academy of Science of the USA, 106, 21527-21532.

17 EEA, 2012.

18 Ice2sea FP7 Research Project http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

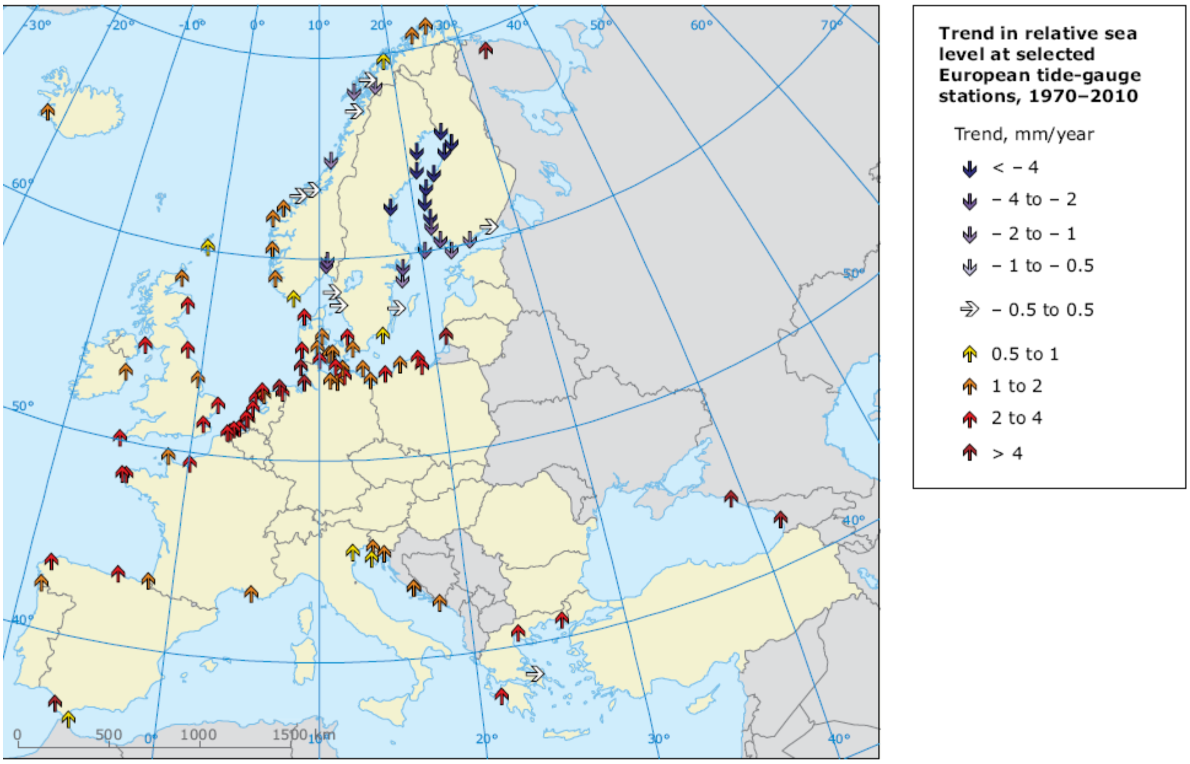

Figure 2 Sea-level changes in Europe [19]

Sea-level rise is not constant over Europe but varies regionally[20]. Geological processes such as post-glacial uplift will have an impact on what is observed at the coast. From 1900-2010, sea level rose around 2mm/year in the North Sea, with the southern-most part experiencing greater change. Both, the Mediterranean and the Baltic Sea have experienced increases and decreases in sea level. While in the Mediterranean Sea the range varies regionally from -4mm/year to +6mm/year, the Sea level of the Baltic is falling in the northern shores and rising to the south. Trends in the Black Sea from 1900-2010 point towards an increase of up to 5mm/year[21]. On the other hand, parts of the English Channel and the Bay of Biscay show a small decrease in mean sea level.

Sea-level rise will increase rates of coastal erosion and increase the severity of storm surges. Land subsidence makes North Sea coasts particularly vulnerable to severe temporary flooding induced by sea storms; research results consistent across various models and scenarios point to moderately higher storm surges in the North Sea in the future

Salt water intrusion into rivers and fresh water aquifers, normally associated with the over exploitation of groundwater resources, could be exacerbated by sea-level rise combined with periods of low river flow, causing salt water intrusion to reach farther points in the river than in times with normal river flow. Salt-water intrusion can threaten freshwater supplies from rivers and coastal aquifers, which not only impacts the drinking water supply but also water

[19] Climate change, impacts and vulnerability in Europe 2012, European Environment Agency, 2012
[20] EEA, 2012.
[21] EEA, 2012.

for irrigation purposes, and ecosystems in coastal areas. Current information on ecological impacts at European scale is lacking[22].

2.1.4. *Ocean acidification*

The ocean absorbs 48% of the carbon emitted to the atmosphere[23]. The carbon chemistry of seawater acts as a buffer, enabling the oceans to hold 50 times more carbon dioxide (CO_2) than the atmosphere can. However, CO_2 absorption by seawater decreases the pH of oceans, leading to its acidification, as well as decreasing carbonate ion (CO_3^{2-}) levels. Under no greenhouse gas emission reduction scenario beyond business-as-usual, atmospheric CO_2 levels could approach 800 ppm by the end of the century, which would imply unprecedented impacts; this will result in a drop in surface water pH from a pre-industrial value of about 8.2 to about 7.8 by the end of this century, increasing the ocean's acidity by about 150% relative to the beginning of the industrial era[24].

CO_2 dissolution in the ocean increases hydrogen (H^+), and thus decreases pH and carbonate ion concentrations. The decrease in carbonate ions reduces the saturation state of calcium carbonate, which directly affects the ability of some calcium carbonate-secreting species, such as planktonic coccolithophores and pteropods, and invertebrates such as molluscs and corals, to produce their shells or skeletons[25]. Reductions in these species may also impact the fish that depend up on them for food. Ocean acidification may influence the structure and productivity of primary and secondary benthic and planktonic production, which in turn may affect the productivity of fish communities and higher trophic levels.

2.1.5. *Coastal erosion*

Coastlines are variously subject to shoreline dynamics such as erosion and deposition of sediments depending on the nature of the coast (hard/rocky or softer sediments) and upon the coastal processes of sediment transport and water movements (waves and currents). Natural coastlines have been extensively modified in many places by coastal defences or damming of rivers to prevent erosion and protect urban infrastructure and agricultural land. Coastal erosion in Europe causes significant economic loss in the order of at least several tens of millions of Euros per year, through property losses and damage to infrastructure and beaches and the required beach nourishment[26]. Wetlands and biodiversity are also affected. About one quarter of the European coastline for which data is available is currently eroding[27], with the Mediterranean, part of the Atlantic and the northern seas presenting the highest risk of erosion.

Climate change can exacerbate coastal erosion, via sea-level rise, increased storminess, higher waves and changes in prevalent wind and waves directions[28].

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22 EEA, 2012.

23 Sabine. C.S., R. A. Feely, N. Gruber, R. M. Key, K. Lee, J. L. Bullister, R. Wanninkhof, C. S. Wong, D. W. R. Wallace, B. Tillbrook, F. J. Millero, T.-H. Peng, A. Kozyr, T. Ono, and A. F. Rios, The oceanic sink for anthropogenic CO2, Science, 305, 367-371.

24 Feely, R.A., S.C. Doney, and S.R. Cooley. 2009. Ocean acidification: Present conditions and future changes in a high-CO2 world. Oceanography 22(4):36–47. http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

25 Feely, et al., 2009.

26 EEA (2012): Climate change, impacts and vulnerability in Europe 2012. An indicator-based report.

27 EEA, 2008.

28 Marchand, 2010 in EEA, 2012.

The impact of storm surges on coastal erosion varies in different regions. Research in Estonia indicates increased beach erosion due to increased storminess in the eastern Baltic Sea[29], while in France the picture varies: for example the Atlantic region is considered resilient to rising sea levels due to extensive dune systems. Whilst the Mediterranean coast is considered more vulnerable because of its narrow dune systems[30].

2.1.6. Coastal wetlands

Coastal ecosystems of mangroves, sea grasses and salt marshes support specialized groups of highly adapted species that are specific to their habitats. The primary production of these halophytic plants supports a high diversity of invertebrates, fish and birds in the near shore environments. Many migratory species depend on tidal wetlands for part of their seasonal migrations. Climate change could influence the timing and routes of these migrations. In addition, coastal erosion contributes to the loss of biodiversity and degradation of these coastal ecosystems.

2.1.7. Thermohaline circulation

Ocean currents are driven by wind and the thermohaline[31] circulation. Ocean currents also have an impact on terrestrial climate. In western Europe the Gulf Stream brings warmer ocean temperatures than the continent’s latitude would normally allow and consequently gives an oceanic climate with milder winters and summers. In light of climate change, researchers[32,33] are concerned that thermohaline circulation could be affected by a reduced rate of water and heat transport, leading to cooling in the northern European oceans near Scandinavia and the UK and at the same time affecting the process of dense water formation in the Mediterranean[34]. The probability that the thermohaline circulation is significantly affected by climate change is still under discussion, but this is being considered as one of the "low probability - high impact" risks associated with global warming.

2.1.8. Marine fish populations

Predictions of the consequences of climate change on marine fish populations are complex. Climate change influences the marine ecosystems by altering temperatures, changing wind patterns, shifting oceanic circulation patterns, increasing ocean acidification and altering precipitation rates and thus salinity. These changes have the potential to change the distribution, abundance, size and behaviour of fish. Changes in migration patterns of fish

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29 Kont et al (2008) in IPCC (2012): Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

30 Vincho et al., 2009 in IPCC 2012.

31 There are three main processes that make the oceans circulate: tidal forces, wind stress, and density differences. The density of sea water is controlled by its temperature (thermo) and its salinity (haline), and the circulation driven by density differences is thus called the thermohaline circulation (Osborn and Kleinen, 2008).

32 Weaver, A. J., J. Sedláček, M. Eby, K. Alexander, E. Crespin, T. Fichefet, G. Philippon-Berthier, F. Joos, M. Kawamiya, K. Matsumoto, M. Steinacher, K. Tachiiri, K. Tokos, M. Yoshimori, and K. Zickfeld (2012), Stability of the Atlantic meridional overturning circulation: A model intercomparison, Geophys. Res. Lett., 39, L20709, doi:10.1029/2012GL053763.

33 http://ec.europa.eu/research/rtdinfo/special_pol/04/print_article_2603_en.html

34 Weaver, et al (2012).

such as mackerel have already been observed. The abundance, distribution and variety of plankton, which are food for small fish, will also change. All things being equal, in warmer waters fish tend to be smaller, and this too could affect the ecosystem[35].

2.1.9. Biodiversity

Sea warming not only affects native aquatic species by limiting and/or expanding their range, it also enables non-native species to expand into regions where they previously could not survive[36]. Where such species become invasive they can cause a decline or even collapse of marine ecosystems[37]. However, opinions vary on the extent of current impact. Some examples of non-native species can be linked to climate change, whereas many more are linked to maritime transport and aquaculture. Climate change has been suggested as one of the principle drivers for the establishment of non-native plant species in the Mediterranean[38] as well as for the expansion of the biogeographical range of benthic and nektobenthic marine species[39]. The introduction of non-native species does not just impact native species, it also causes 'ecosystem cascading effects'[40].

The potential changes noted above to fish communities are also applicable to other types of marine biodiversity, although much remains uncertain about the nature and extent of such changes. Changes in species distribution, abundance, reproductive capacity, behaviour and growth rates are possible. The effects of ocean acidification are potentially wide-ranging, particularly affecting species with calcareous skeletons such as coccolithophores, molluscs and corals, but also possibly affecting fish behaviour. Any such changes to individual species would have consequences for the species composition of the different marine ecosystems and affect preditor-prey relationships.

2.1.10. Eutrophication

Eutrophication affects all major seas in Europe, especially the Baltic Sea. An OSPAR Commission report[41] suggests that climate change could indirectly increase eutrophication problems in coastal waters. Assessment[42] of combined future impacts of climate change and industrial and agricultural practices in the Baltic Sea catchment on the Baltic Sea ecosystem

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35 Cheung, W., Sarmiento, J., Dunne, J., Frölicher, T., Lam, V., Deng Palomares, M.L., Watson, and Pauly, D. (2012): Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems, Nature Climate Change Letters, DOI: 10.1038/NCLIMATE1691.

36 Walther, G-R.; Roques, A.; Hulme, P.; Sykes, M.; Pyšek, P.; Kühn, I.; Zobel, M.; Bacher, S.; Botta-Dukát, Z.; Bugmann, H.; Czúcz, B.; Dauber, J.; Hickler, T.; Jarošik, V.; Kenis, M.; Klotz, S.; Minchin, D.; Moora, M.; Nentwig, W.; Ott, J., Panov, V.; Reineking, B.; Robineet, C.; Semenchenko, V.; Solarz, W.; Thuiller, W.; Vilá, M.; Vohland, K.; Settele, J. (2009): Alien spicies in a warmer world: risks and opportunities. Trends in Ecology and Evolution 24(12): 685–691.

37 Harris and Tyrel, 2001; Stachowicz, et al., 2002, Frank et al, 2005 in Occhipinti-Amrogi, A. (2007): Global change and marine communities: Alien species and climate change. Marne Pollution Bulletin 55, p.342-352.

38 Gritti, et al., 2006 in Occhipinti-Ambrogi, 2007.

39 Francour et al., 1994, Vacchi et al., 1999; Bianchi and Morri, 2000, Laubier et al., 2004 in Occhipinti-Ambrogi, 2007.

40 An ecological cascade effect is a series of secondary extinctions that is triggered by the primary extinction of a key species in an ecosystem. Secondary extinctions are likely to occur when the threatened species are: dependent on a few specific food sources, mutualistic(dependent on the key species in some way), or forced to coexist with an invasive species that is introduced to the ecosystem.

41 OSPAR (2010): Quality Status Report 2010. OSPAR Commission. London.; http://www.ospar.org/.

42 Meier, H.E.M, H. Andersson, H, . Dieterich, C., Eilola, E., Gustafsson, B., Höglund, A., Hordoir, R. and S. Schimanke, 2011. Transient scenario simulations for the Baltic Sea Region during the 21st century. SMHI, Rapport Oceanografi Nr 108

showed that the impact of nutrient load reductions according to the Baltic Sea Action Plan[43] will be less effective in future climate compared to present climate and that policy makers should act to avoid much worse environmental conditions than today. While climate change will not directly affect the source of the problem (increased nutrient loads into the sea originating from household discharges and fertiliser use in agriculture), increased rainfall and its associated flooding and increased surface run-off from land could thus load rivers that discharge into coastal areas with increased nutrients[44]. Changes in ocean acidity may also affect eutrophication through changes in atmospheric absorption rates.

2.2. Socio-economic implications

2.2.1. Estimating impacts with and without adaptation

Approximately 52 million people in Europe live in low-elevation coastal zones (LECZ) covering 481, 695 km^2.[45] Especially in north-western Europe, high population densities living in coastal zones could pose a considerable concern in the future with regard to a changing climate and the impacts this will have on local economies. Overall, in Europe an estimated 13 million people would be negatively affected by a one-metre rise in seal level[46]. For instance, sea level rise (in combination with storm surges) could increase the risk of flooding, coastal erosion and salt water intrusion to groundwater resources and to rivers/deltas and estuaries in these areas.

Some studies have tried to assess the economic and social implications of climate change in coastal areas. Hinkel et al. (2009[47], 2010[48]) suggest that the UK, the southern part of the Baltic coast and the north-western Mediterranean coast are highly vulnerable to sea level rise flooding, especially in a high-greenhouse gas emission climate scenario. Under a no-adaptation scenario, it is estimated that between 200,000 (low-emission scenario) and 780,000 people (high-emission scenario) people could be affected by coastal flooding by 2100.

The Climate Cost project[49] assessed the potential economic impact of climate change in Europe's coastal zones using the DIVA model. The E1 emissions scenario, which is broadly consistent with a 2 °C temperature rise scenario, projects a 0.27m sea level rise for Europe.

43 http://www.helcom.fi/BSAP/en_GB/intro/

44 HELCOM, 2007. Climate Change in the Baltic Sea Area, chapter 6.1.1: nutrient inputs http://www.helcom.fi/stc/files/Publications/Proceedings/bsep111.pdf

45 Vafeidis, A., Neumann, B., Zimmermann, J., and Nicholes, R.J. (2011): Migration and Global Environmental Change. MR): Analysis of land area and population in the low-elevation coastal zone (LECZ). Final Report of the UK Government's Foresigh Project.

46 Endlicher, Wilfried & Gerstengabe, Friedrich-Wilhelm (eds.) (2007): Der Klimawandel – Einblicke, Rückblicke und Ausblicke. Potsdam Institut für Klimafolgenforschung e.V., Potsdam.

47 Hinkel, J.; Nicholls, R.J.; Vafeidis, A.T.; Tol, R.S.J.; Exner, L.; Avagianou, T. (2009): The vulnerability of European coastal areas to sea level rise and storm surge. Contribution to the EEA SOER 2010 report, Potsdam Institute for Climate Impact Research (PIK).

48 Hinkel, J.; Nicholls, R.J.; Vafeidis, A.T.; Tol, R.S.J.; Avagianou, T. (2010): Assessing risk of and adaptation to sea-level rise in the European Union: an application of DIVA. Mitigation and Adaptation Strategies for Global Change (2010) 15: 703–719.

49 The ClimateCost project took into account damage and adaptation costs. Damage costs include: total annual damage costs (2005 price), including the number of people forced to move due to erosion and submergence (assuming the cost for people that move is 3x the value of their per-capita GDP; land-loss costs (land below the 1-in1 year flood level) taking into account dikes and direct erosion ignoring nourishment, salinisation costs and the expected costs of sea and river floods. Adaptation costs include the sum of sea dikes, river dikes and beach nourishment.

Projections under a medium to high emission scenario (A1B) estimate a 0.37 m sea level rise for Europe in the 2080s. Without further upgrade on coastal protection, this would translate into average estimated damage costs of €25 billion annually[50]. The analysis also suggests that European wetlands will be heavily impacted, leading to economic loss that have not yet been fully valued[51].

Effective adaptation action can significantly reduce the negative impacts associated with climate change on coastal zones. To take an example, the ClimateCost study shows that the avoided costs due to adaptation action from the impacts of sea level rise in the EU are estimated, depending on the climate scenario, around EUR 3,5bn (A1B) and 4bn (E1) per year in the 2020s, around EUR 8,6bn (A1B) and 9,9bn (E1) per year in the 2050s, and around EUR 22,7bn (A1B) and 15,4bn (E1) per year in the 2080s[52].

2.2.2. Fisheries and aquaculture

Warmer, more acidic seawater will clearly have an impact on sea-life and therefore on fisheries and aquaculture, with potential economic implications, and requiring adaptation action[53].

Marine species can either adapt to the changing conditions or move to new areas with similar conditions to what they are used to. The complex nature of ecosystems and the interaction between species including humans means that it is not possible to predict exactly what will happen but, all things being equal, one can expect a shift northwards. According to the EU research project CLAMER[54] "*There is clear evidence from all European seas that rising temperatures, along with overfishing, are causing substantial changes to fish stocks such as herring, sand eels and cod, as well as to their ranges and migration routes. Warmer water fish species are gradually moving north so that unfamiliar fish species are now appearing on fish market stalls*."

For the future CLAMER expects "*Northerly extension of warmer-water fish is expected to continue, with development of new exploitable populations. Stocks of cold-adapted species are projected to decline in, for instance, the North Sea, but to benefit from higher temperatures in areas such as the Barents Sea. Fish production is sensitive to the combined effects of climate, ocean acidification and plankton community changes, and heavily exploited fish stocks are likely to be especially vulnerable*."

Warmer waters may increase the growth rate for aquaculture species but can also place some species outside their comfort zone. Rising acidity may affect the ability of shellfish to construct their shells. In Oregon acidity spikes have been observed that kill oyster larvae or

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50 Such estimates should always be qualified before interpretation: they are necessarily influenced by the assumptions made for the modelling exercise. For instance, only one temperature profile was used for projections. Other important parameters include socio-economic projections (e.g. changes to population, population density and gross national product) and economics (e.g. exchange rates, discount rates).

51 Brown S, Nicholls RJ, Vafeidis A, Hinkel J, and Watkiss P (2011): The Impacts and Economic Costs of Sea-Level Rise in Europe and the Costs and Benefits of Adaptation. Summary of Results from the EC RTD ClimateCost Project.In Watkiss, P (Editor), 2011.The ClimateCost Project.Final Report. Volume 1: Europe. Published by the Stockholm Environment Institute, Sweden, 2011.ISBN 978-91-86125-35-6.

52 Brown, S., Nicholls, R., Vafeidis, A., Hinkel, J. and Watkiss P. (2011) Sea-Level Rise on Coastal Zones in the EU and the Costs and Benefits of Adaptation: Summary of Sector Results from the ClimateCost project, funded by the European Community’s Seventh Framework Programme,

53 EEA 2012

54 http://www.clamer.eu/

stunt their growth[55]. More research is needed to assess Europe's important shellfish industry's vulnerability to rising acidity.

2.2.3. Coastal tourism

Coastal tourism is by far the most significant contributor to the tourism industry in Europe, both in terms of tourist numbers and generation of income[56]. Coastal tourism is also the largest single maritime economic activity[57]. Climate plays a major role in the popularity and success of tourist destinations and therefore tourism income. Climate change is expected to "reshape" the tourism industry and will impact the geographical and seasonal distribution of tourists[58]. In the Mediterranean, tourism is likely to shift away from the summer and become more attractive in the spring and autumn. In northern Europe, good months for coastal tourism are expected to increase[59].

2.2.4. Transport and energy

Seaports play a crucial role in the global economy as transportation hubs for the vast majority of goods transported around the world. Their operations are prone to the impacts of sea-level rise , increased storm intensity, and flooding Many port authorities are aware of such issues and have taken a series of measures to address them[60].

Sea level rise and sea storms are likely to increase risks of inundation and erosion of coastal road transport networks, causing disruptions in the transport of goods and in the mobility of local communities. Moreover, increased inspections and repairs may become necessary due to erosion of transport structures due to inundation and saline intrusion.

Energy production located in coastal areas may be threatened by climate change induced storm surges, sea-level rise and flooding. Therefore the siting of future plants must take into account climate scenarios[61]. Moreover, risk assessments, such as in the UK following the adoption of the Climate Change Act, are ongoing about existing energy infrastructure assets. Regarding nuclear power plants for instance, based on the recent stress tests conducted at EU level, the national regulators concluded that there are no technical reasons requiring the immediate shutdown of any nuclear power plant in Europe, and identified a series of good practices. However, various technical upgrade measures have been identified and among the recommendations, European guidance should be developed on the assessment of natural hazards, including earthquake, flooding and extreme weather conditions, and safety margins, in order to increase consistency between Member States[62]. The issue of climate change and

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55 Robert F. Service Rising Acidity Brings an Ocean of Trouble Science 13 July 2012

56 European Commission (2008): The Impact of Tourism on Coastal Areas: Regional Development Aspects. DG for Internal Policies of the Union, Policy Department B: Structural and Cohesion Policies, Brussels. www.europarl.europa.eu/activities/expert/eStudies.do?language=EN.

57 ECORYS (draft): Blue Growth. Scenarios and drivers for Sustainable Growth from the Oceans, Seas and Coasts. Report for the European Commission, DG MARE.

58 EC, 2008.

59 UNWTO (2008): Climate Change and Tourism. Responding to Global Challenges.

60 See for instance the example of the port of Rotterdam presented in the CSWD on adaptation to climate change infrastructure (SWD(2013)137)

61 Urban, F., and Mitchel, T., (2011): Climate change, disasters and electricity generation. Strengthening Climate Resilience Discussion Paper 8, Institute of Development Studies: Brighton.

62 COM(2012)571 final

impacts on the energy infrastructure, including in coastal areas, is discussed further in the CSWD on infrastructure[63].

2.2.5. *Agriculture*

Impacts of climate change on agriculture are expected to be increasingly visible towards 2050, when climatic changes intensify. In extreme cases, a reduction in suitable areas for cultivation in certain European regions can be expected[64] . For instance, farmland in coastal areas may decrease considerably in the future, due to the potential increase of flooding and inundation of fields. In addition, saltwater intrusion of groundwater aquifers could negatively impact sources for irrigation and therefore crop yield could be indirectly affected if suitable alternatives are not available.

2.2.6. *Ecosystems and their services*

Coastal ecosystems such as dunes and barrier beaches, salt marshes and mangroves are delivering a wide range of services to humans. They cover storm and flood protection[65], erosion control, recreation and tourism, carbon storage, food production and habitat provision). The ability of the ecosystems to deliver their services might be negatively affected by intensifying climate change – information is currently collected on mapping and assessing state and trends of those services, and on how to invest in ecosystem-based solutions through Green Infrastructure and restoration[66]. Given their multi-functional properties, green infrastructure along the coastline line could help protected coastal areas against erosion and flooding as well as protection sensitive coastal ecosystems such as brackish waters and tidal pools. Green Infrastructure can provide water retention services, thereby mitigating the impacts of extreme events like floods and seasonal water scarcity. Better functioning ecosystems can also contribute to integrated planning/management and erosion control in coastal zones. Restoring ecosystems such as barrier beaches or coastal wetlands reduces the exposure of human communities to disasters, such as landslides, flooding, storms and wave surges.

2.3. Remaining knowledge gaps

Remaining knowledge gaps on climate change impacts on coastal areas, marine ecosystems and maritime sectors relate to four broad categories: global drivers; local impacts; socio-economic drivers and adaptation costs and benefits:

– Global drivers: further observations and research are needed to better understand the interactions between oceans-atmosphere which are essential elements of the planet´s climate machinery as well as to reduce uncertainty in phenomena that have an impact on global sea-level rise, in particular the melting of ice in Greenland and Antarctica,

63 SWD(2013)137

64 Olesen and Bindi 2004; Olesen et al. 2011; Iglesias et al. 2009

65 Coastal flood defence – The Alkborough Flats managed realignment scheme on the Humber Estuary, England, has delivered benefits for coastal flood protection and reduced and deferred expenditures on man-made coastal defences. The scheme is estimated to deliver an annual flood protection benefit of £400,667(€465,000), giving total benefits with a present value of £12.2 million (€14million), as well as other benefits for wildlife and ecosystem services. The scheme cost £10.2 million (€11.8million) and involved the restoration of tidal habitats on 440 ha of agricultural land. – In: Naumann, S. Davis McK., Kaphengst T., Pieterse M. and Rayment M. (2011): Design, implementation and cost elements of Green Infrastructure projects. Final report to the European Commission, DG Environment.

66 http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm

or on ocean acidification. This could help in adaptation policy- and decision-making. This would also provide more insight into low probability-high impact scenarios.

– Regional and local impacts: further observations are needed at a regional and local level on changes in temperature, seawater acidity, coastal erosion and ecosystems. Such consequences could then be used for better climate risk assessments in coastal and marine economic sectors, and likewise, better informed adaptation action.

– Socio-economic drivers: additional work is needed to better estimate the evolution of population, economic growth, and land cover and their impacts on marine and maritime economic sectors, as well as their impacts on urban and rural development in coastal areas. This would help national and regional authorities develop the most appropriate and cost-effective strategy for coastal protection.

– Adaptation costs and benefits: additional research is needed on the costs and benefits of alternative adaptation actions in coastal areas. For instance, some of the benefits have not been monetized, like the assessment of the implications of ecosystem-based adaptation measures.

3. EXISTING ADAPTATION EFFORTS

Natural variation and human activities are constantly altering the marine and coastal environment. Demographic change and evolving economies are having an impact on the vulnerabilities of coastal regions and the marine and maritime economies. Climate change adds then one more layer to this complex environment. A number of EU instruments exist to deal with these challenges, and this section presents in particular how climate change has been addressed in that context.

3.1. Current policy framework at EU level and related adaptation efforts

3.1.1. Water Framework and Floods Directives

In coastal areas, the Water Framework Directive[67,68]covers transitional waters and coastal waters up to one nautical mile from the territorial baseline of a Member State for a Good Ecological Status and up to 12 nautical miles for a Good Chemical Status. In the context of the implementation phase of this Directive[69], almost half of river-basin management plans specifically address specific climate change adaptation measures.[70]

The Floods Directive[71] also provides attention to the impacts of coastal floods. In early 2012, Member States reported to the European Commission preliminary flood risk assessments of their river basins and associated coastal zones to identify areas where potential significant flood risk exists. The assessment of the reported data has started and should also draw attention to the extent to which climate change has already been considered.

[67] Water Framework Directive (2000/60/EC).

[68] The Proposal on a General Union Environment Action Programme to 2020 "Living well, within the limits of our planet" (7EAP) points out the need to take environmental concerns into account in the maritime sector and emphasises the need to ensure that by 2020 the environmental objectives of the WFD and the MSFD are met.

[69] CIS guidance document No. 24 River Basin Management in a Changing Climate

[70] EC (2012): Commission Staff Working Document, European Overview (2/2) Accompanying the document, “Report from the Commission to the European Parliament and the Council on the Implementation of the Water Framework Directive (2000/60/EC) River Basin Management Plans.

[71] 2007/60/EC.

In 2009, the Water Directors of the EU Member States issued a guidance document on adaptation to climate change in water management[72]. The guidance provides approaches on how to take climate change into account in the implementation of the Water Framework Directive, the Floods Directive and the Strategy on Water Scarcity and Droughts. Moreover, the Common Implementation Strategy activity on "Climate Change and the EU Water Policy" aims to, among other things, "identify what can and should be done in the different upcoming River Basin Management planning cycles" in relation to climate change impacts and adaptation.

3.1.2. Marine Strategy Framework Directive (MSFD)

The Marine Strategy Framework Directive[73], the environmental pillar of the Integrated Maritime Policy (IMP) is aiming for the implementation of an integrated, adaptive and ecosystem-based approach to the management of human activities at sea and on the coast. The objective is to achieve, by 2020, the Good Environmental Status (GES) of all European marine and coastal waters.

3.1.3. Integrated Coastal Management

In March 2013 the Commission adopted a proposal[74] for a Directive establishing a framework for maritime spatial planning and integrated coastal management. The proposal aims to ensure that the growth of increasing maritime activities at sea and the use of resources at sea and on coasts remain sustainable. The proposed action will require Member States to establish maritime spatial plans and integrated coastal management strategies by applying an ecosystem-based approach that, among others, should contribute to ensuring climate resilient coastal and marine areas. The integrated coastal management strategies should build on the principles and elements set out in the 2002 Recommendation[75] on Integrated Coastal Zone Management and the Protocol on Integrated Coastal zone Management to the Barcelona Convention (the Convention on the Protection of the Mediterranean Sea against Pollution)[76], the first legally-binding international instrument specifically dedicated to integrated coastal management and ratified by the EU in 2010[77].

This Recommendation outlines a strategic approach to the management of land and sea spaces and defines eight principles of sound coastal planning and management that should be followed by Member States when formulating national coastal strategies[78]. The implementation of these principles has been reinforced, in particular through the adoption of the Integrated Maritime Policy (IMP)[79] in 2007, aiming to address issues arising from a fragmented management of EU's marine waters through the implementation of tools such as

72 European Commission (2009): Guidance Document no. 24. River Basin Management in a changing climate.

73 2008/56/EC.

74 COM(2013)final; http://ec.europa.eu/environment/iczm/home.htm

75 Council Recommendation of the European Parliament and the Council of 30 May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe. Recommendation 2002/413/EC, OJ 148, 6.6.2002, p.24. Brussels: European Commission.

76 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:034:0019:0028:EN:PDF.

77 Council Decision 2010/631/EU

78 These principles are: 1. A broad overall perspective, both thematic and geographic; 2. A long-term approach, taking into account the precautionary principle; 3. Adaptive management; 4. Local specificity and diversity; 5. Working with natural processes and respecting the carrying capacity of ecosystems; 6. Involvement of all parties concerned; 7. Support of relevant administrative bodies and improved coordination; 8. Use of a combination of instruments.

79 COM(2007) 757 final.

integrated coastal management and maritime spatial planning[80]. An important step for integrated coastal management was the adoption of the ICZM Protocol to the Barcelona Convention (the Convention on the Protection of the Mediterranean Sea against Pollution)[81] in 2008, the first legally-binding international instrument specifically dedicated to ICZM.

In the 2009 White Paper on adapting to climate change, the Commission announced the development of guidelines on adaptation in coastal and marine areas to ensure a coordinated and integrated approach to adaptation in coastal and marine areas. The Commission is aiming to develop such guidelines in order to support Member States on the implementation of integrated coastal management strategies.

3.1.4. Natura 2000, Habitats and Birds Directives

The Natura 2000 network of areas of high biodiversity value, established under the Habitats and Birds Directives[82] , protects a large share of coastal and marine regions. The priority to protect marine ecosystems and their aquatic species has been reinforced by the EU 2020 Biodiversity Strategy[83]. The effective management and restoration of Natura 2000 sites reduces non-climate pressures and increases resilience to climate change. The Commission services will shortly issue guidelines on climate change and Natura 2000 targeted at site managers and policy makers. This will underline benefits from Natura 2000 sites in mitigating the impacts of climate change, reducing vulnerability and increasing resilience, and how adaptation of management for species and habitats protected by Natura 2000 can be used to tackle the effects of climate change[84]. The establishment of green infrastructure and other ecosystem-based approaches to adaptation can be promoted by this framework, which can increase the resilience of coastal areas to climate change. The possible movement of species due to changing climate outside their present protection zones will require an adaptive management approach.

3.1.5. Support tools and information dissemination

In order to strengthen the exchange of good practice examples on adaptation and coastal zone management, the following tools have been created over the last years:

- Climate-ADAPT[85]: The European Climate Adaptation Platform was launched in March 2012. It has been developed to share information on adaptation case studies throughout the EU and potential adaptation options in order to help users (e.g. researchers, policy makers) develop their own climate change adaptation policies. Coastal areas and Marine and Fisheries are two of the sectors covered by the database (alongside agriculture, biodiversity, health, etc).
- OURCOAST[86]: The OURCOAST database is a comprehensive compilation of hundreds of case study summaries that reflect successful cases of integrated coastal

[80] Communication from the Commission to the Council, the European Parliament, the European Economic and Social committee and the Committee of the Regions - Towards a future Maritime Policy for the Union: A European Vision for the Oceans and Seas/* COM/2006/0275 final */.

[81] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:034:0019:0028:EN:PDF.

[82] (92/43/EEC).

[83] Communication from the Commission to the European Parliament, the council, the economic and social committee and the committee of the regions (2011): Our life insurance, our natural capital: an EU biodiversity strategy to 2020, COM(2011) 244 final.

[84] I.M. Bouwma, C. Vos, M. Biemans, N. McIntosh, R. van Apeldoorn & P. Verdonschot (2012): Guidelines on dealing with the impacts of climate change on the management of Natura 2000. Luxembourg: Publications Office of the European Union.

[85] http://climate-adapt.eea.europa.eu/web/guest/home.

[86] http://ec.europa.eu/ourcoast/index.cfm?menuID=3.

management applied throughout Europe, including many cases focusing particularly on climate change adaptation information and communication systems, planning and land management instruments, and institutional coordination mechanisms.

- EMODnet[87]: A European Marine Observation and Data Network (EMODnet) was initiated in 2006 and finalized in 2008. EMODnet is a common gateway for researchers and service providers of high quality marine data — geological, hydrographic, chemical, biological and physical habitats — as well as of the human activities that have an impact on our seas and oceans.
- WISE-Marine[88]: The marine component of WISE (Water Information System for Europe)[89] is currently under development and should incorporate the information reported by the Member States under the MSFD (except the underlying datasets which should be incorporated into EMODnet).

3.1.6. EU funding

Several projects on adaptation in coastal and marine areas have been initiated over the last years, funded or co-funded. The European Commission provides several funds (the CSF funds, LIFE+ funds, research funds) that foster cooperation between Member States and regions in terms of climate change. Under the Multi-Annual Financing Framework (MFF) [90]. it has been agreed that the climate related expenditure will represent at least 20% in the period 2014-2020.

"Promoting climate change adaptation, risk prevention and management" is one of the eleven priorities of the Commission's proposal for a Common Strategic Framework which provides a common set of rules for the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund (CF), the European Agricultural Fund for Rural Development (EAFRD) and the future European Maritime and Fisheries Fund (EMFF).

In particular, climate change (adaptation and mitigation) is to be integrated into the five specific Union Priorities which will be pursued under the EMFF, namely increasing employment and territorial cohesion in fisheries areas, fostering innovative, competitive and knowledge based fisheries, promoting a sustainable and resource efficient fisheries, fostering innovative, competitive and knowledge based aquaculture, and promoting a sustainable and resource efficient aquaculture.

Research into adaptation to climate change are included within the societal challenge "climate action, resource efficiency and raw materials" of the Commission's proposal for a research programme, Horizon 2020[91].

The proposed regulation of the LIFE 2014-2020 programme also include elements relevant for coastal zones as indicated in the Communication on an EU Strategy on adaptation to climate change (COM(2013)XXX).

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87 http://www.emodnet-hydrography.eu/.
88 https://webgate.ec.europa.eu/maritimeforum/category/554.
89 http://water.europa.eu/
90 http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/135344.pdf
91 Proposal for a Regulation Of The European Parliament And Of The Council establishing Horizon 2020 The Framework Programme For Research And Innovation (2014-2020) COM(2011) 809 final

3.2. Efforts at Member State level and within the EU marine regions

3.2.1. Member States' efforts

National and local authorities are well aware that Europe's coastlines are not fixed in time but are constantly changing. The construction of sea-walls and the nourishment of beaches is standard practice. Three broad classes of intervention can be distinguished

(1) protection: through sea-walls or hard structures

(2) managed retreat: abandoning land to the sea

(3) accommodation – for instance through reinforcement of dunes or through wetlands that allow periodic flooding

The choice of a class of intervention is site-specific, depending on pattern of relative sea-level change, geomorphological setting, sediment availability and erosion, as well a series of social, economic and political factors.

The Netherlands spend about €700 million a year on dyke maintenance including levees on the sides of rivers and canals and also dikes, levees and seawalls that border seashores, bays and estuaries. Another €100 million is spent on softer measures such as dune nourishment. The UK's Environment Agency spends up to €200 million a year on measures to protect populations in England and Wales against coastal flooding. The most significant infrastructure is the Thames Barrier, opened in 1984 to protect London against exceptionally high tides and storm surges. Its operational lifetime was expected to end in 2030 subject to appropriate modification, it is expected to provide continued protection to London against rising sea levels until at least 2070. . Damages caused by storm Xynthia[92] in France in 2010 have triggered the establishment of the national floods management plan (budget allocation of €500million) including an action programme with 60 concrete floods prevention actions. Other examples of infrastructure projects within coastal zone management include the M.O.S.E. project[93] in Venice or the Delta project in the Netherlands[94].

Following the adoption of the Recommendations on Integrated Coastal Zone Management in 2002, Member States have taken important steps towards legislative approval for their national strategies and their implementation[95], including aspects related to climate change adaptation.

Member States have taken two types of approaches to integrating climate change adaptation in their coastal zone management[96]: 1) through specific coastal strategies/frameworks and 2) through general climate change adaptation plans/frameworks). In addition, efforts have been complemented by research activities funded through regional/national funding and through LIFE+ and INTERREG programmes. Projects on adaptation include work on coastal erosion, coastal defences, flooding, controlling development, rehabilitation works and sea level rise.

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92 http://www.euromedcp.eu/index.php?option=com_content&view=article&id=715%3Axynthia-storm-one-year-later-strong-actions-in-france-to-prevent-floods&catid=917%3Ams&Itemid=960&lang=en

93 http://paratoie.intesesrl.com/en/mose-project.html.

94 http://www.deltawerken.com/23.

95 Reporting in 2006 and 2010 http://ec.europa.eu/environment/iczm/nat_reports.htm stated that 6 Member States (FI, DE, MT, PT, RO, UK) have implemented national ICZM in line with the recommendations and an additional 8 Member States (BE, CY, EL, FR, LV, NL, SL, PL) have implemented strategies or programmes equivalent to ICZM.

96 Based on information collected at the Joint Eionet and Member State Expert Group workshop on Maritime Spatial Planning-Integrated Coastal Zone Management, which took place in September 2012.

As of January 2013, 15 countries have adopted national adaptation strategies and action plans, of which 13 Member States have identified and addressed coastal areas and management in their national adaptation policies and seven have considered fisheries and aquaculture[97]. A more detailed assessment of the adaptation strategies of the different marine sea regions will be carried out in 2013/14 by a Commission service contract "Sharing of best practices on Integrated Coastal Zone Management, in a context of adaptation to climate change in coastal areas[98]".

3.2.2. Sea basins

The Helsinki Commission (HELCOM)'s 2007 Action Plan[99] highlighted the need for action to combat the impact climate change will have on the Baltic Sea region. The EU Strategy for the **Baltic**[100] indicates the need to prepare for more extreme weather events, highlighting 'to mitigate and to adapt to climate change' as one of its priority areas. Baltic 21, an Expert Group within the Council of Baltic Sea States aims to develop an adaptation strategy for the region.

BaltCICA ("Climate Change: Impacts, Costs and Adaptation in the Baltic Sea Region", running from 2009 to 2012)[101] is a project that aims to prepare regions and municipalities to cope with climate change impacts by developing transnational adaptation actions. The BaltAdapt project[102] (2010-2013) is developing a transnational Baltic Sea Region-wide climate change adaptation strategy, but focus on the sea itself and its coastline. RADOST[103] is a national project that focuses on adaptation strategies for the Baltic coastline of Germany.

In 2009, the OSPAR Commission, a cooperation between 15 governments to protect the marine environment of the **North-East Atlantic**, developed an assessment of climate change mitigation and adaptation. In terms of marine adaptation, it proposed to promote the resilience of ecosystems already under pressure from other human activities, such as operational quotas (e.g. fisheries catch), protection for sites, adaptation of environmental objectives or inclusion of climate change in the management of maritime activities. It advocated increased monitoring, integrated coastal zone management and maritime spatial planning.

In the sub-region of the North Sea, the Safecoast project[104] examined coastal flood and erosion risk management and its evolution in the field of climate change by 2050.

The **Mediterranean** Action Plan (MAP), implemented by the Barcelona Convention[105], is promoting integrated coastal zone management as the most effective way to improve the ecological state of the sea and help coastal communities adapt to climate change. The Protocol[106] on Integrated Coastal Zone Management is established under the Barcelona Convention and binding to Mediterranean states.

[97] EEA report on adaptation in Europe, 2013.
[98] ENV.D.2/SER/2012/0037.
[99] HELCOM Ministerial Meeting, Krakow, Poland, 15 November, 2007 http://www.helcom.fi/stc/files/BSAP/BSAP_Final.pdf.
[100] COM(2009) 248 final
[101] http://www.baltcica.org.
[102] http://www.baltadapt.eu/.
[103] http://www.klimzug-radost.de/.
[104] http://www.safecoast.org.
[105] http://europa.eu/legislation_summaries/environment/water_protection_management/l28084_en.htm
[106] OJ L 34, 4.2.2009; http://ec.europa.eu/environment/iczm/barcelona.htm

The "CIRCE Integrated Project - Climate Change and Impact Research: the Mediterranean Environment"[107] aims at predicting and quantifying physical, social and economic impacts of climate change in an integrated way. The MAREMED project[108] aims to better evaluate the impacts of climate changes in coastal areas at both a Mediterranean and a local operational level, particularly regarding extreme climate events. The PEGASO project[109], aims to develop an integrated coastal management governance platform for the Black Sea and Mediterranean regions.

The 1992 Bucharest Convention and its latest Strategic Action Plan include a consideration on the impacts of climate change on **Black Sea** ecosystems and sustainable development along coastal areas as a short-medium term target[110]. The project"Climate proofing the Danube Delta through integrated land and water management" analyses the possible impacts of climate change on the Danube Delta region and a climate change adaptation strategy for this region.

3.2.3. Outermost regions

The specificities of the outermost regions require special attention. Research on the climate change vulnerability in the outermost regions is on-going although priority is often given to understanding risks rather than to adaptation projects[111].

Moreover, outermost regions are investing in adaptation relevant measures, generally defined as responses to natural risks such as flooding and erosion. The financing for these measures is estimated at around €237 million from 1998 and 2015[112]. In addition, the EU's BEST[113] initiative aims to promote the sustainable use of biodiversity and ecosystem services through practical examples, including ecosystem based approaches to climate change adaptation and mitigation, a specific priority action in 2011.

In the Canary Islands, an Adaptation Strategy is being developed following the adoption of the Climate Change Mitigation Strategy in 2009. Previous studies have looked specifically at the impacts on coastal shoreline infrastructure and construction. The Azores and Madeira have Coastal Management Plans covering coastal defense against flooding, erosion or extreme weather events. The French regions of Guiana, Guadeloupe, and Martinique have recently developed the regional schemes presenting assessments of vulnerability to climate change in their territories and have identified coastal erosion and the loss of coastal ecosystems (e.g. coral bleaching) as a major concern. As for Reunion and Mayotte, the Indian Ocean Commission (IOC) has identified coastal zone management as a line of action for a future Regional Strategy for Climate Change Adaptation.

107 http://www.circeproject.eu.

108 http://www.maremed.eu/.

109 http:// www.pegasoproject.eu/.

110 http://www.blacksea-commission.org/_convention.asp. The 1992 Bucharest Convention was followed in 1996 by a Strategic Action Plan, which was revised in 2009 by the Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea, which adheres to three key environmental management approaches including ICZM.

111 An on-going EU funded project is considering in more detail the economic impacts of climate change in outermost regions and adaptation measures.

112 Policy Research Corporation (2009): The economics of climate change adaptation in EU coastal areas

113 Voluntary scheme for Biodiversity and Ecosystem Services in Territories of the EU Outermost Regions and Overseas Countries and Territories. The BEST preparatory action had an annual budget € 2 million in the years 2011,2012 and 2013

3.2.4. Arctic regions

The Ottawa Declaration of 1996[114] established the Arctic Council, an international forum which promotes cooperation, coordination and interaction among the Arctic countries. One of its six Working Groups dedicated to 'Sustainable Development' has 'adaptation to climate change' as one of its thematic areas. The 'Center for International Climate and Environmental Research-Oslo' (CICERO)[115] developed the VACCA[116] project (Vulnerability and Adaptation to Climate Change in the Arctic) which aimed to collect and disseminate information on research and adaptation strategies or measures, and to organize international workshops about vulnerability and adaptation to climate change.

In 2012, the European Parliament and the Council published a joint communication "Developing a European Union Policy towards the Arctic Region: progress since 2008 and next steps"[117] in which they develop the will of the European Union to step up its engagement with its Arctic partners to jointly meet the challenges of climate change by increasing its contribution to Arctic research through 'Horizon 2020'[118], by enhancing monitoring and surveillance capabilities and reinforcing its funding for sustainable development in the Arctic Region.

4. FURTHER ADAPTATION EFFORTS NEEDED

4.1. Better informed decision making

Significant effort has been made to determine how climate change will affect the different sea regions in the future. Much of the research under the IPCC focussed on global trends with some regional analysis, in the last five years considerable work has been done to develop models at the sea region level. In addition national research has produced quite important results for Member States. However, single national data and global assessment alone does not give a complete picture on the current state of European seas and coasts. The integration of national research at EU level and the breakdown of global assessments to the different EU sea regions are essential to better understand how the different European sea and coastal regions are and will be affected by climate change in the future. Several gaps still remain (as described in the section above): large data ranges of potential impacts, for example on sea level rise, still create uncertainty and some impacts on the environment and on certain economic sectors are still poorly understood[119].

The European Commission is working to overcome these knowledge gaps and the bottlenecks regarding the coherent collection of marine data. As the 2010 Communication on the Marine Knowledge 2020 Strategy[120] points out, data are being held by hundreds of different institutions in the EU - hydrographic offices, geological surveys, local authorities, environmental agencies, research institutes, universities, and much of the data is not compatible with one another. The Marine Knowledge 2020 Strategy is seeking to bring together marine data from different sources to improve our understanding of sea regions and with the aim to help the private sector, public authorities and researchers obtain data and make more effective use of them. This will also allow developing more sound adaptation

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114 http://www.arctic-council.org/index.php/en/about/documents/file/13-ottawa-declaration.
115 http://www.cicero.uio.no/projects/detail.aspx?id=30233&lang=EN.
116 http://library.arcticportal.org/1481/.
117 JOIN(2012) 19 final.
118 See http://ec.europa.eu/research/horizon2020/index_en.cfm.
119 EEA, 2012.
120 COM(2012) 473 final.

possibilities. Encouraged by this Strategy, the European Commission aims to improve communication amongst national data centres through regular discussions in its marine observation and data expert groups and its maritime internet forum in order to promote good practice in data collection and dissemination.

In particular highlighted was the link between the Marine Knowledge 2020 Strategy and climate change by the opinion of the Committee of the Regions, calling "for a more structured approach to marine observations in order to deliver more accurate indicators of local changes in climatic parameters such as sea-level rise and ocean acidification to the Climate-ADAPT platform and therefore help the process of adapting to climate change"[121].

EMODnet is complementary to other EU initiatives on information services, and its parameters will feed directly into indicator reporting by the Member States for the MSFD through WISE-Marine. Analyses of the 2012 reported data under the MSFD will provide a better picture on each Member States' situation as regards pressures, and impacts to the marine environment.

The European Earth monitoring programme (GMES)[122] and its ocean service aims at delivering products and services that added-value service providers can build on to provide services to public and private users. Under the GMES programme, a marine service has been progressively developed, focusing on observation and providing near-real time and forecasted information on the oceans, and is being further developed with the GMES climate service.

In order to make most use of all this information, future work of the Commission[123] is aiming to link existing databases, such as OURCOAST, EMODnet, WISE-Marine and Climate-ADAPT and the GMES marine service. All the data sources mentioned above could be complemented by the information collected under the WFD and Floods Directive. This will allow the Commission and Member States as well as international sea conventions to better implement existing and forthcoming EU policies.

Beyond ensuring access to data, dissemination pathways to better inform all levels of policy making and implementing should be strengthened. Thereby structures already in place for example under the WFD Common Implementation Strategy the group on water and climate change and the informal Member State expert groups on Maritime spatial planning and integrated coastal management could be used. Special focus should be paid to the local level, where adaptation takes place. The publication of data and analysis in differing national languages currently presents a barrier for good exchange of regional information across national boundaries. Cooperation between the European Commission Member States could be enhanced to ensure that EU level actions in the field of knowledge generation are followed up at the local level.

There have been many research projects funded in the last 10 years, focussing on adaptation strategies in marine areas. Established working groups at EU level could be used to more broadly disseminate research results. In addition a dedicated science-policy interface could be established to allow the different sea regions to communicate their experiences with one another and exchange best practice on maritime spatial planning and integrated coastal managementand on adaptation options.

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[121] See draft opinion of the Commission for Natural Resources (NAT) 13th NAT meeting on 5 December 2012 (NAT-V-024).

[122] http://ec.europa.eu/enterprise/policies/space/gmes/.

[123] ENV.D.2/SER/2012/0037 "Sharing of best practices on Integrated Coastal Zone Management, in a context of adaptation to climate change in coastal areas".

4.2. Increasing the resilience of the EU territory

Cooperation among Member States to address these transboundary hazards (prevention and disaster relief) is therefore essential for a proper coastal management reaction to increasing climate change impacts. In practice it is not always easy to implement: a holistic coastal and marine risk management (encompassing prevention, protection, preparedness, emergency response, recovery and review) that includes joint monitoring and forecasting, coordinated risk assessments and planning of measures requires the appropriate legal and institutional framework.

The MSFD and the Floods Directive offer a framework at Community level to reduce risks from natural hazards such as geological or weather-related. The Commission will further support this process via the Common Implementation Process for the WFD, MSFD and Floods Directive.

The principles of maritime spatial planning and integrated coastal management should not only be taken up on the national level but would also benefit the sea regions by being fully integrated into their sea conventions and strategies. Complementing these strategies, regional disaster risk management plans could formulate regional approaches to reducing risks from natural hazards and improving the preparedness and response to natural disasters and accidents. Disaster risk management plans could be coordinated with the management requirements of the WFD, the Floods Directive and the MSFD and cooperation working groups could be established to strengthen the link between these directives and their requirements.

Climate change adaptation has been addressed in various ways by the EU sea regions already as a cross-cutting issue but not all basins so far have developed comprehensive strategies. Such strategies should address all economic sectors and would greatly enhance the work of the Member States and better target necessary adaptation measures. These regional adaptation strategies for each marine basin should provide a cross-reference to the proposal on maritime spatial planning and integrated coastal management that contains a clear and explicit link to ensuring climate resilient coastal and marine areas. Cooperation among the Member States should be crucial, but also work with business stakeholders together with local administrations and researchers in a transparency manner would increase acceptability of the strategy itself.

To support the work at Member State, regional and local level, the Commission will develop a set of guidance documents to support the implementations of various climate relevant policies:

- As already mentioned under point 3.1.3, the European Commission is committed to develop guidelines on best adaptation practices in coastal and marine areas in the context of the implementation of integrated coastal management strategies.
- The Commission could consider further support to Member States, regional and local authorities in implementing climate change proofed policies in coastal and marine areas, in particular by highlighting the benefits of green infrastructure (as proposed by the "Blueprint to safeguard Europe's water"[124]).

[124] http://ec.europa.eu/environment/water/blueprint/index_en.htm.

4.3. Increasing the resilience of key vulnerable sectors:

Increasing the resilience of key vulnerable sectors in coastal and marine zones, has two aspects: On one hand existing EU sector mechanism can be used, on the other hand the role of the private sector in adaptation could be strengthened. In this context the following activities are considered:

- The proposal for the European Maritime and Fisheries Fund (2013-2020) requires that Member States shall take into account a pertinent approach towards innovation and climate change mitigation and adaptation when designing their operational programs. The Commission will help Member States with this new task by providing guidance at an early stage in order to strengthen the resilience of the fishery sector.

- In the context of proper policy implementation the Commission will also ensure that the MSFD implementation, in particular GES (Good Environmental Status) and measures are climate proofed, through the revision of the GES Decision 2010/477/EU by 2015. This will secure the environmental bases for sectors such as fisheries, tourism.
- In the context of the blue growth initiative the Commission has outlined a certain set of activities where additional effort at EU level could stimulate long-term growth and jobs in the blue economy, in line with the objectives of the Europe 2020 strategy. In order to ensure that these objectives are successful, climate change needs to be factored in.
- Traditionally the management and protection of coastal zones fall predominantly into public responsibilities. However, even at this early stage of implementing adaptation (measures), potential private sector contributions including provision of innovative adaptation technologies and services have been identified for several coastal areas. As such the private sector offers a distinct opportunity to support climate change adaptation by providing data, funding, insurance and taking adaptation measures. In order to strengthen these efforts the potential role of the private sector" to complement coastal adaptation measures (e.g. see for example the Project Waterdunen in the NL[125]) could be explored.

The on-going and already announced actions – including in the Communication on an EU Strategy on adaptation to climate change – set out in Annex I are of particular relevance to support the achievement of the objectives of the EU Strategy on adaptation to climate change.

[125] The project combines tourism with nature conservation and coastal protection on a private base. See http://www.waterdunen.com/.

5. ANNEX I: OVERVIEW OF SET OF ACTIONS

Proposed actions	Basis	By when?	Who will take it?
Seek for ways for private companies to provide data from licensed activities	Marine Knowledge 2020 Strategy	Impact Assessment in 2013 which will elaborate on details	European Commission Private sector
Linking existing databases, such as OURCOAST, EMODnet, WISE-Marine, CLIMATE-ADAPT and the GMES marine service	EU Strategy on Adaptation to climate change DG ENV Service Contract	From 2013 onwards	European Commission EEA
A science-policy interface could be established to allow the different sea regions to communicate their experiences with one another and exchange best practice on maritime spatial planning and integrated coastal managementand on adaptation options	EU Strategy on Adaptation to climate change, Marine Strategy Framework Directive (2008/56/EC), proposal for a Directive establishing a framework for maritime spatial planning and integrated coastal management	From 2013 to 2020	European Commission Member States Sea Conventions
Revision of the GES Decision 2010/477/EU	Decision 2010/477/EU	2015	European Commission
Help Member States in reducing risks from natural hazard due to the Common Implementation Process for the WFD, MSFD and Floods Directive	Marine Strategy Framework Directive (2008/56/EC), Water Framework Directive (2000/60/EC)	2013-2015	European Commission Member States Sea Conventions
Guidelines on best adaptation practices in coastal and marine areas to be developed within the framework of the ICZM recommendation and Commission proposal on	White Paper on adaptation towards climate change, proposal for a Directive Establishing a framework for Maritime Planning and Coastal Management,	2014	European Commission

MSP/CM / ICZM recommendation / MSFD	ICZM recommendation		
Development of Disaster risk management plans, in coordination with the Floods Directive management plans (FRMP)	Floods Directive 2007/60/EC	By end 2015 for the 1st FRMP cycle, to be reviewed at the latest every 6 years thereafter	European Commission Member States Sea Conventions
"Sharing of best practices on Integrated Coastal Zone Management, in a context of adaptation to climate change in coastal areas	DG ENV Service Contract	2014	European Commission
Guidance for EMFF 2014-2020	EU Strategy on adaptation to climate change	2013	European Commission